EFFECT OF *BACILLUS THURINGIENSIS* VAR. *ISRAELENSIS* UPON THE PREDATORY CAPACITY OF *BUENOA* SP. (HEMIPTERA: NOTONECTIDAE) AGAINST *CULEX PIPIENS QUINQUEFASCIATUS* (DIPTERA: CULICIDAE) LARVAE.[1]

Eduardo A. Rebollar- Téllez, Norma Gorrochotegui- Escalante Martin Reyna- Nava, Adriana Solis- Santamaría.[2]

ABSTRACT: The predatory capacity of *Buenoa* sp. was evaluated with *Culex pipiens quinquefasciatus* larvae. We determined two parameters of predation: searching capacity (a´) and the handling time (th). Both estimates were calculated when the prey was untreated and when it had been treated with *Bacillus thuringiensis* var. *israelensis*. Also, the mortality exerted by the predator, the predator plus *B.t.i.*, and by *B.t.i.* alone were evaluated. In general, predation was greater when predator and bacteria were present than when each one was used separately.

The mosquito *Culex pipiens quinquefasciatus* Say (Diptera: Culicidae) is an important vector of arboviruses and filarial worms. Commonly, arthropod-borne diseases are controlled by controlling their vectors with chemical insecticides. Use of insecticides presents two complications: insect resistance, and pollution of the environment (Metcalf 1990). With microbial control, these problems can be avoided. The purpose of this work was: 1) to evaluate the predatory capacity of *Buenoa* sp. alone, and of *B.t.i.* together with the predator, and 2) to determine mortality exerted by the predator alone, by *B.t.i.* plus predator, and by *B.t.i.* alone.

MATERIALS AND METHODS

Mosquitoes were collected in the Pesquería river, Escobedo, Nuevo Leon, Mexico. Egg rafts were placed in plastic pans until eclosion. The notonectid predator *Buenoa* sp. was collected in an urban area of Monterrey, N. L. Identification of mosquitoes and notonectids was done using keys in Darsie and Ward (1981) and Polhemus (1983). Larvae were placed into 1 L glass containers containing 750 ml of dechlorinated water (pH 6.5). Individual predators of either the third or fourth instar were used to one of 10 densities of prey larvae. These were 1,3,5,7,10,20,30,40,50 and 60 larvae /750 ml of water. Each larval density was exposed to one predator to each larval density, replicated five times. To compare prey consumption by predators against untreated or treated larvae of different body sizes, we selected one group of larvae

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[2] Universidad Autonoma de Nuevo Leon, Facultad de Ciencias Biológicas, Laboratorio de Entomología Médica. Apdo. Postal 109-F, San Nicolás de los Garza, N.L. México.

containing first and second instars, and a second group containing third and fourth instars. In the first experiment, we used a single predator in each larval density described above; first to first plus second instar larvae, then to a second group of third plus fourth instar larvae.

For a second experiment, we evaluated the action of the predator, plus Bactimos® (*Bacillus thuringiensis* var. *israelensis* Biochem Products, San Antonio, TX), at the recommended dosage (9.3 gr/m2). This experiment was conducted in the same way as the first experiment, first plus second instar larvae and third plus fourth instar larvae.

We recorded the number of prey consumed after 24 h. All treatments were conducted at 14: 10 light- darkness regime, and the average temperature was 24°C. Results were analyzed with linear regression (Zar 1984) and were compared with Holling's functional responses equation type II $Na = a' TtNo / (1 + a' ThNo)$. In that equation *(Na)* denotes the number of successful attacks per predator during the time of exposure of prey to the predator *(Tt)* ; *(No)* denotes the initial density of prey; and *(a')* and *(Th)* represent the rate of successful attack and the time required to handle the prey, respectively. The *(a')* and *(Th)* values were determined by means of the linear transformation of Holling's equation: $Na/No = a' Tt - a' ThNa$ (Holling 1959). An X^2 test for goodness of fit between observed and expected values was performed for both models.

Finally, we conducted a third experiment using the same number of larvae as in the first and second experiments: first plus second instar larvae and third plus fourth instar larvae. In this experiment Bactimos® was used without predators. The numbers of dead larvae were recorded after 24 h.

RESULTS AND DISCUSSION

For a first experiment the linear regression equation was Y= 1.8357 + 0.5320X, where Y is the number of prey consumed after 24 h, and X is the prey density. This result was obtained for the first plus second instars. For third plus fourth instars it was Y= 2.0154 + 0.4214*X*. To determine whether or not the slopes of these lines were significantly different, we used a "t" test, which indicated that both slopes were not different ($P < 0.05$). This indicates that the predation rate exhibited by *Buenoa* sp. was the same, and was independent of prey body size. Using Holling's equation, a searching capacity of (a') = 0.0342 and a handling time of (th) = 0.2399 were determined for the first plus second instars, and (a') = 0.0259, (th) = 0.1646 for the third plus fourth instars. Despite apparent differences between the (a') values, we believe that antipredation responses of C. *pipiens quinquefasciatus* to escape this predator were basically the same.

Linear regression for the predator combined with *B.t.i.* gave Y= 0.3523 + 0.9837*X* and Y= 1.8256 + 0.7546*X* for first plus second, and for third plus fourth instars respectively, In the same way as for the predator alone, we again

performed the "t" test, finding in this case a significant difference between both slopes ($P < 0.05$). These results suggest that the third plus fourth instar larvae were less susceptible to Bactimos® than were first plus second instars. Holling's parameters were (a´) = 0.0381, (th) = 0.0355 for first and second instars, (a´) = 0.0420, and (th) = 0.1222 (Table 1.) for the third and fourth instars.

B.t.i. was also tested alone for *C. pipiens quinquefasciatus* larvae to determine the mortality of each treatment. Means were 1) 70.06% for predator alone, 2) 94.5% for *B.t.i.* plus predator, and 3) 99.2% for *B.t.i.* alone upon the first plus second instars. For the third plus fourth instars, mortality was 1) 57.2% for the predator alone, 2) 91.2% for *B.t.i.* plus predator, and 3) 66.2% for *B.t.i.* alone.

The results for Holling's parameters (a´) and (th) are similar to the findings of Pérez (1990) who reported a searching capacity value of 0.02954 and the handling time of 1.02159 for the predator *Buenoa* sp. On the other hand, Ortegon and Quiroz (1990) tested the predatory capacity of *Buenoa* sp. adults upon *C. pipiens quinquefasciatus.* In that study, they evaluated both parameters (a´) and (th) when the predator was alone, and when the predator was present with a strain of *Bacillus thuringiensis* var. *israelensis.* They found that the (a´) value was incremented, and the (th) value was decreased when the bacterium was present. Our results in this study corroborate their findings. Perhaps *B.t.i.* reduced larval strength, thereby diminishing anti-predator response, since moving is the key factor for larvae to avoid being consumed (Sih 1986). Bacterial action might have reduced larval capacity to escape from the predator. This effect was marked in the first and second instars.

Larvae of *Culex pipiens quinquefasciatus* and third and fourth nymphal instars of the predator *Buenoa* sp. have been deposited as voucher specimens in the Nuevo Leon University (accession number: ER- 01- 92 for both species).

TABLE 1. Results of the Holling's equation of the searching capacity (a') and the handling time (th) of *Buenoa* sp. alone, and with the *Bacillus thuringiensis* var. *israelensis*

	Predator alone		Predator with *B.t.i.*	
Larval Stages	(a´)	(th)	(a´)	(th)
I plus II	0 . 0342	0 . 2399	0 . 0381	0 . 035
III plus IV	0 . 0259	0 .1646	0 . 0420	0 .122

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